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Natural Regeneration in Two Central Idaho Grand Fir Habitat Types

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RESEARCH SUMMARY

This survey of natural regeneration of five conifer species, ranging in age from 3 to 10 years, on two major habitat types in the grand fir zone of central Idaho, is a part of a larger study on the succession and management of the habitat types. The two habitat types—grand fir/white spirea and grand fir/mountain maple—represent environments ranging from warm, dry to mesic. Sample sites varied in age from 5 to 24 years since disturbance and represented four harvest-regeneration methods (clearcut, group selection cut, seed-tree cut, and shelterwood cut) and four site preparation treatments (no site preparation, burning, and light and heavy scarification). Safe site characteristics for individual conifer seedlings were recorded. Seedlings were summarized by numbers per acre for different treatments. Safe site variables were compared with ratio analysis, which was used to calculate a "regeneration efficiency" value.

Recommendations for obtaining natural regeneration vary primarily by habitat type. In the warm, dry grand fir/white spirea habitat type, natural regeneration requires site protection for establishment. In the mesic grand fir/mountain maple habitat type, tall shrub development may preclude early seral conifer species. The need for site protection in the grand fir/white spirea habitat type and the tall shrub potential in the grand fir/mountain maple habitat type likely accounts for the differences in seedling safe sites characteristics found for some conifer species.

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INTRODUCTION

Traditionally in central Idaho, many silviculturists have relied on planting conifer seedlings for reforestation rather than on natural conifer regeneration, primarily because cone crops are unpredictable (Curtis and Foiles 1961). Sometimes, however, natural regeneration may be an attractive alternative to planting. To gain the most from natural regeneration, large numbers of seedlings must result from each cone crop. Managers can increase the likelihood of capturing seeds from cone crops by providing many suitable, well-dispersed microsites. These microsites or "safe sites" (Harper 1977) must supply the resources for both seed germination and seedling establishment. A safe site includes both the soil surface (seedbed) and cover (or lack of cover) usually from vegetation and debris. Existing safe sites are often modified by disturbance because disturbance often alters seedbeds and covers. In addition, different conifer species on the same site may require different safe sites, and seedling composition could be altered by altering safe site availability (Harper and others 1965).

The objectives of this study were:

1. To determine the composition of existing natural regeneration in two central Idaho grand fir (*Abies grandis*) habitat types.
2. To identify potential natural regeneration safe sites.
3. To determine harvest-regeneration and site preparation treatments conducive to obtaining natural regeneration.
4. To develop recommendations for obtaining natural regeneration in two central Idaho grand fir habitat types.

Central Idaho Grand Fir Habitat Types

Steele and others (1981) have identified nine central Idaho grand fir habitat types, of which two are included in this report: the grand fir/white spirea (*Abies grandis/Spiraea betulifolia* [ABGR/SPBE]) habitat type and the grand fir/mountain maple (*Abies grandis/Acer glabrum* [ABGR/ACGL]) habitat type. Both habitat types are widespread throughout the central Idaho grand fir zone.

The grand fir habitat types are in moderate forest environments on sites that are more moist than the Douglas-fir habitat types and warmer than the subalpine fir habitat types (Steele and others 1981). These productive habitat types support large numbers of understory and overstory species; most of the conifer species in central Idaho occur in some part of the grand fir zone.

The ABGR/SPBE habitat type occurs in the warmer, drier extreme of the grand fir zone from 4,300 to 6,400 ft (1,300 to 1,950 m) on south-facing to west-facing upper slopes. The ABGR/ACGL habitat type, a moderate habitat type compared to ABGR/SPBE habitat type, occurs from 3,800 to 6,400 ft (1,160 to 1,950 m) on north to east aspects on mid to lower slopes. Two phases, *Acer glabrum* (ACGL) and *Physocarpus malvaceus* (PHMA), further delineate the ABGR/ACGL habitat type. The ACGL phase occurs on more moist sites than the PHMA phase; the PHMA phase represents a warmer, drier environment in the ABGR/ACGL habitat type. I treated the ABGR/ACGL habitat type as a single unit for most of this report and noted differences between the phases where necessary.

Conifers in the Grand Fir Habitat Types

Though six conifer species occur in the grand fir zone, the importance of individual species depends on the habitat type (table 1). By definition the climax species, grand fir, is found throughout the two habitat types; however, Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) are also common. Engelmann spruce (*Picea engelmannii*), western larch (*Larix occidentalis*), and lodgepole pine (*Pinus contorta*) occur in some areas.

Western larch and lodgepole pine are both early seral. Western larch grows most commonly on warmer, more moist sites. Lodgepole pine occurs primarily on cooler sites, and when it is found in large quantities, it may indicate a frost pocket. In this case, it may be the only species that can successfully regenerate immediately following a disturbance, even when other species are present.

Ponderosa pine and Douglas-fir are both mid-seral species in the grand fir habitat types. Douglas-fir is

Table 1—Role of conifer species for two central Idaho grand fir habitat types (Steele and Geier-Hayes 1988, 1989)

Species	ABGR/SPBE	ABGR/ACGL	
		ACGL phase	PHMA phase
Lodgepole pine	(S)[1]	(s)	a
Western larch	(s)	(s)	(s)
Ponderosa pine	S	(S)	S
Douglas-fir	S	S	S
Englemann spruce	a	(S)	a
Grand fir	C	C	C

[1]C = major climax; S = major seral; s = minor seral; ( ) = occurs in part of the habitat type; a = accidental.

commonly found throughout. However, ponderosa pine is most common in ABGR/SPBE and the PHMA phase of ABGR/ACGL (Steele and Geier-Hayes 1988, 1992). Though ponderosa pine may be present in stands at cooler or more moist extremes of the habitat types, careful examination of the sites may reveal that these ponderosa pine are restricted to rare microsites (Steele and Geier-Hayes 1992). Attempts to reproduce such stands to a monoculture of ponderosa pine, even through planting, have often failed.

Engelmann spruce is a late seral species usually restricted to moist sites. It is more common in the ACGL phase of ABGR/ACGL than in the PHMA phase and is rarely found in ABGR/SPBE.

Factors Influencing Natural Regeneration Establishment

Natural regeneration success depends on several factors. One is the environment. Habitat type classification provided a straightforward method for categorizing the environment for this survey, where environment is considered relatively rather than empirically. For example, from information available through the habitat type classification (Steele and others 1981) and without having to measure temperature and precipitation, we know that sites classified as ABGR/SPBE habitat type are warmer and drier than sites classified as ABGR/ACGL habitat type

Seed availability is another obviously important variable affecting natural regeneration. Availability depends on seed dispersal and cone crop periodicity. Though seed dispersal can be accomplished via a variety of mechanisms, wind is the most common for the six conifers in this survey. "Average" dispersal distances of seed from the six conifers vary depending on the morphology of the seed and its weight. Minore (1979) rates ponderosa pine seed as the heaviest of the six species and western larch as the lightest. Even though seed of the heaviest species can disperse miles on boisterous wind currents, practical dispersal distances are much shorter. Alexander (1986) defined effective seeding distance as the farthest point from a seed source that enough seed is dispersed to provide an acceptable stocking level of the target species. Alexander also noted that effective seeding distances depend on both environment and site conditions. Therefore, within habitat types, effective seeding distances may differ depending on the site conditions remaining after disturbance.

Another important variable is the safe site—the seedbed and the microenvironment immediately surrounding the seedbed. The seedbed may determine whether a seed will produce a seedling. For example, if a seed's radicle must penetrate thick organic debris to reach mineral soil before upper soil layers begin to dry, its chances of survival are reduced compared to a seed germinating on mineral soil. On the other hand, organic debris may act as a mulch, which would reduce soil moisture losses longer into the summer compared to exposed mineral soil (Krauch 1956). In this case, organic debris may provide a more beneficial seedbed than mineral soil. Any place a seed lands could be considered a seedbed, but the most common potential seedbeds following disturbance are mineral soil, mineral soil covered with litter, residual duff, moss mats, rotten wood, logs, and stumps.

A seedbed's surrounding microenvironment is part of the safe site. For example, the microenvironment around a seedbed in the open differs greatly from the microenvironment of a seedbed under a tree or shrub cover. Light quality and quantity, soil moisture, humidity, temperature, and windspeeds under a cover are usually different from the open (Zavitkovski and Woodard 1970). Determining a cover's influence on a safe site is difficult because covers could be at one time beneficial and another time detrimental. This is especially true for vegetative covers; while vegetation may ameliorate the microenvironment, perhaps creating a safe site, the vegetation is at the same time withdrawing nutrients and water and intercepting sunlight. For this reason, safe sites that allow for seed germination and even seedling establishment may eventually impede seedling growth.

Some vegetative species may be useful as safe site covers because of their symbiotic relationships, or may be harmful by virtue of their physiology. Potential cover species that form relationships with nitrogen-fixing organisms may benefit seedlings by providing nutrient-rich safe sites. In central Idaho, snowbrush ceanothus (*Ceanothus velutinus*) (Conard and others 1985) and Sitka alder (*Alnus sinuata*) (Mitchell 1968) support nitrogen-fixing organisms and thus may benefit seedlings. Potentially harmful covers are those vegetative species that produce chemicals that may prevent establishment or retard growth of individuals germinating near them (allelopaths). Brackenfern

(*Pteridium aquilinum*) (Ferguson and Boyd 1988), sagebrush (*Artemisia* spp.) (Muller 1966), and elderberry (*Sambucus racemosa*) are examples of potential allelopaths.

The selected harvest-regeneration method influences natural regeneration by determining the postdisturbance site conditions, the seed availability, and the safe sites. Soil surfaces of clearcut sites receive more solar radiation and often more precipitation than soil surfaces of shelterwood cuts, where the overstory partially intercepts both sunlight and moisture. Other environmental conditions such as windspeed and temperature vary between sites treated with different harvest-regeneration methods.

METHODS

Data were collected from the grand fir zone in the Payette and Boise National Forests of west-central Idaho as part of a larger study of the classification and management of seral vegetative communities (Steele and Geier-Hayes 1988, 1992). Sampling was conducted in various habitat types, including the two for this report, from 1979 through 1987. Areas identified as ABGR/ACGL and ABGR/SPBE habitat type were reconnoitered to identify stands with timber harvesting disturbance. Sample sites were selected to represent the available harvest-regeneration and site preparation treatments.

One or more 0.1-acre (0.04-ha) circular sample plots were located within sample sites in areas with uniform treatments and vegetative communities. Sample plots were designated subjectively, by their appearance and function, as clearcuts, seed-tree cuts, shelterwood cuts, or group selection cuts.

Site preparation treatments were assigned based on the source and amount of disturbance to the residual duff and underlaying soil. Categories were none (no slash disposal and little disturbance to residual duff or soil from harvesting), burned (either broadcast burned or underburned), and scarified—light scarification (removal or incorporation of residual duff and minor disturbance to the top 6 inches (15.2 cm) of soil from slash disposal or harvesting) and heavy scarification (removal of residual duff and the top 6 inches (15.2 cm) or more of soil from contour terracing, contour stripping, or intensive brush removal). A scarification percentage was estimated for each sample plot based on the amount of area affected by the site preparation treatment or harvesting activity.

Within each 0.1-acre sample plot, five 108-ft^2 (10-m^2) circular subplots were located with one at the center of the 0.1-acre plot and four peripheral at 22.5 ft (6.9 m) relative to the middle of the center subplot. Two subplots were located perpendicular to the contour with one above and one below the center subplot, and two were located on the contour with one to the left and one to the right of the center subplot. A primary assumption using this layout was that safe sites were randomly dispersed within the uniform treatment.

In most cases, a 0.1-acre sample plot (consisting of the five subplots) was surveyed within a sample site depending on sample site size, treatment uniformity, and available vegetative communities (to meet the requirements of the larger study). Occasionally, more than one site preparation treatment could be defined for a sample site. For example, a sample site with an incomplete broadcast burn could provide area assigned as broadcast burned or as scarified. In this case, more than a 0.1-acre sample plot could be surveyed within the same sample site.

The percentage of each subplot covered by defined soil surfaces and percent cover of vegetation and debris were recorded. I then recorded the species and safe site characteristics of every seedling in the subplot. I defined a safe site as a 6-inch-radius cylinder with the seedling in the center, extending from the soil surface and up indefinitely. The safe site characteristics were recorded as the predominant soil surface and safe site cover. Soil surface categories were bare mineral soil, litter-covered mineral soil, moss mat, residual duff, and rotten wood. Rocks and stumps were recorded as nonstockable soil surface covers even though a few seedlings were found on stumps or in cracks of rocks. Safe site covers were vegetation and debris closest to the seedling within the cylinder area. Safe sites without cover or debris within the cylinder area were considered open.

I recorded seedlings that were between 3 and 10 years old that had established since the disturbance. Seedlings were clipped and aged in the laboratory or, when possible, were aged on site by counting bud scars or nodes. Each individual seedling or cluster of seedlings (cache) was recorded as one seedling occurrence. For each sample site, I recorded aspect, slope, and elevation. The dates (year) of timber harvesting and site disturbance came from management records, plantation signs, tree growth release indications from increment borings, and cross sections of equipment scars resulting from the timber harvesting.

For most comparisons data were summarized by habitat type and 5-year age groups based on years since disturbance. For harvest-regeneration and site preparation treatments, data were summarized by calculating number of seedlings per acre. Data were summarized for seedlings within soil surface covers and under safe site covers using ratio analysis (Groot 1988). Ratio analysis compares the percentage of, for example, seedlings against the percentage of a soil surface cover based on constancy (percentage of subplots in which the soil surface was present) and percent cover. I used ratio analysis because soil surface and safe site covers were estimated by percentage of subplot occupied, and ratio analysis compares seedling

quantities against the amount of soil surface or safe site cover available. The result of the ratio analysis I call the "regeneration efficiency" value. A regeneration efficiency of 1.00 indicates that seedling numbers and soil surface or safe site cover amounts were in proportion to each other. For example, if 80 percent of the seedlings occurred on bare mineral soil, and bare mineral soil accounted for 80 percent of the sample area, the relationship between the seedlings and soil surface cover is 1.00 (1 to 1). Indexes greater than 1.00 indicate that more seedlings occurred within a soil surface or safe site cover category than the occurrence of the category, and indexes less than 1.00 indicate that fewer seedlings were found. Regeneration efficiency values were subjectively grouped into classes:

Class 1: 0 to 0.25, very inefficient
Class 2: 0.26 to 0.75, inefficient
Class 3: 0.76 to 1.50, neutral
Class 4: 1.51 to 3.00, moderately efficient
Class 5: 3.01 or greater, very efficient

Though this survey was done after the initial establishment of seedlings, Groot (1988), studying seedbed receptivity analysis methods, stated that ratio analysis is feasible on sites where seedbeds do not change much through time. In my survey, I used soil surface cover categories of bare mineral soil, litter-covered mineral soil, moss mats, rotten wood, and residual duff. Bare mineral soil, rotten wood, and residual duff probably had not changed much during the time between the disturbance and the survey and could likely be defined as "seedbeds." I could not, however, determine the "seedbeds" of seedlings established on litter-covered mineral soil or moss mats. For this reason, I have used the term "soil surface covers" for all categories.

RESULTS AND DISCUSSION

A total of 100 sample plots (35 ABGR/SPBE and 65 ABGR/ACGL) were sampled ranging in age from 5 to 24 years after disturbance (table 2). Average number of seedlings per acre was highest at 881 in the warm, dry ABGR/SPBE habitat type. The composition of early, mid, and late seral species was quite uniform between the habitat types (fig. 1). In both, late seral species accounted for more than half of the regeneration, and of that, the climax species, grand fir, accounted for the most. Mid-seral Douglas-fir made up almost one-quarter of the regeneration. Early seral species were most poorly represented, possibly due to the infrequency of successful cone crops in both ponderosa pine and western larch (Curtis and Foiles 1961; Minore 1979; Shearer 1989).

In the ABGR/ACGL habitat type, more seedlings were found in plots disturbed 5 to 9 years before sampling than in older sample plots. The ABGR/ACGL habitat type supports several tall shrub species that, when present, resprout vigorously following disturbance, and certain site preparation treatments provide ideal seedbed for tall shrubs coming from seed. Under these conditions, safe sites for early seral, shade-intolerant

Table 2—Average number of 3- to 10-year-old seedlings per acre by 5-year age groups (years since disturbance) for two central Idaho grand fir habitat types

Habitat type and species	Years since disturbance 5-9	10-14	15-19	20-24	Average
Grand fir/white spirea habitat type					
No. of stands	**10**	**10**	**7**	**8**	
Western larch	130	0	35	20	49
Ponderosa pine	0	16	0	20	9
Douglas-fir	194	389	139	30	201
Grand fir	340	1,044	902	212	622
Total	644	1,449	1,076	282	881
Grand fir/mountain maple habitat type					
No. of stands	**24**	**19**	**12**	**10**	
Western larch	135	34	0	0	61
Ponderosa pine	34	51	27	0	32
Douglas-fir	162	124	216	8	137
Engelmann spruce	307	4	13	0	117
Grand fir	250	234	283	105	229
Total	888	447	532	113	576

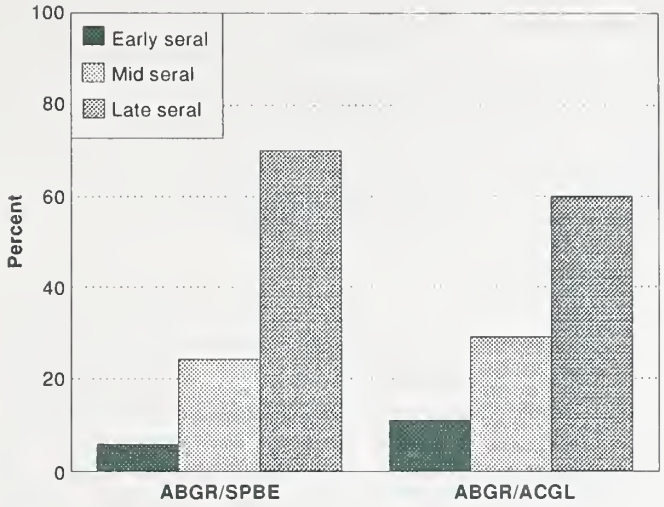

Figure 1—Average percent composition of early, mid, and late seral/climax conifer species in two central Idaho grand fir habitat types.

species likely disappear quickly. The distribution of seedlings in different-aged sample plots supports this trend. In the 5 to 14 years following disturbance, about 20 percent of the seedlings were of early seral species. However, in 15- to 19-year-old sample plots, the regeneration was mostly mid and late seral species. For sample plots in the 20- to 24-year period, late seral species accounted for most of the regeneration. The total number of seedlings in the 20- to 24-year-old sample plots, however, were only a fraction of the total number of seedlings found on 5- to 9-year-old sample plots.

In the ABGR/SPBE habitat type, more regeneration occurred in the 10- to 19-year-old sample plots. Because of warm, dry conditions in ABGR/SPBE, regeneration appears more often in ameliorated safe sites (table 3). In ABGR/SPBE, no western larch, Douglas-fir, and only a small number of grand fir seedlings were found in the open in clearcuts, seed-tree cuts, or group selection cuts, without a safe site cover. Most seedlings occurred under safe site covers or in shelterwoods. Safe sites created by shrub canopy covers may take 5 or more years to develop, especially on severely disturbed sites. This may account for the smaller amount of regeneration in the 5- to 9-year-old sample plots compared to the 10- to 19-year-old sample plots. In ABGR/ACGL, many more seedlings, especially of early seral western larch and ponderosa pine, occurred in the open. At 15 years after disturbance, a smaller percentage of the regeneration was found uncovered. Because ABGR/ACGL supports several large shrub species, after 15 years shrubs may totally occupy the site providing little open space for early seral conifers. This may account for the lack of regeneration in the 20- to 24-year age group.

Reduced shrub development and subsequently reduced shrub competition in ABGR/SPBE compared to ABGR/ACGL may explain the larger average number of seedlings. In ABGR/ACGL, the number of suitable safe sites may quickly decline from shrub competition. The drier ABGR/SPBE habitat type supports fewer shrub species, which possibly increases the longevity of suitable safe sites.

Table 3—Percentage of uncovered[1] 3- to 10-year-old seedlings by 5-year age groups (years since disturbance) for two central Idaho grand fir habitat types

Habitat type and species	Years since disturbance			
	5-9	10-14	15-19	20-24
Grand fir/white spirea habitat type				
No. of stands	**10**	**10**	**7**	**8**
Western larch	0	0	0	0
Ponderosa pine	—[2]	—	—	—
Douglas-fir	0	0	8	0
Grand fir	1	15	4	5
Grand fir/mountain maple habitat type				
No. of stands	**24**	**19**	**12**	**10**
Western larch	43	25	—	—
Ponderosa pine	30	17	0	—
Douglas-fir	6	7	5	—
Engelmann spruce	21	—	—	—
Grand fir	12	11	2	0

[1]Uncovered = in a clearcut, seed-tree cut, or group selection cut without a safe site cover. Covered seedlings were those in shelterwoods or with a safe site cover.
[2]Insufficient data or not present.

Harvest-Regeneration Methods

Distribution of sample stands in different age groups likely reflects common past harvest-regeneration practices (table 4). For example, few seed-tree cuts or shelterwood cuts were found in the 20- to 24-year age group; the best distribution of these harvest-regeneration methods occurred more recently, as reflected in the 5- to 9-year age group. Clearcutting was the most common harvest-regeneration method in the older sample stands. Clearcut size averaged between 3 and 4 acres (1.2 and 1.6 ha) in both types; group selection cuts averaged 0.5 acres (0.2 ha) (table 5).

Shelterwood cuts in ABGR/SPBE appear to regenerate more successfully compared to other sampled methods (table 4). Shelterwood cutting likely ameliorates potentially harsh site conditions in this warm, dry habitat type. More seedlings were found on sites with 26 percent or more overstory cover than on sites

Table 4—Average number of 3- to 10-year-old seedlings per acre by 5-year age groups (years since disturbance) and harvest-regeneration method for two central Idaho grand fir habitat types

Habitat type and species	Years since disturbance: 5-9 CC[1]	5-9 GS	5-9 ST	5-9 SW	10-14 CC	10-14 GS	10-14 ST	10-14 SW	15-19 CC	15-19 GS	15-19 ST	15-19 SW	20-24 CC	20-24 GS	20-24 ST	20-24 SW	Average CC	Average GS	Average ST	Average SW
Grand fir/white spirea habitat type																				
No. of stands	**2**	**1**	**2**	**5**	**3**	**1**	**4**	**2**	**3**	**3**	**0**	**1**	**7**	**1**	**0**	**0**	**15**	**6**	**6**	**8**
Western larch	0	0	0	259	0	0	0	0	27	0	—[2]	162	12	81	—	—	11	13	0	182
Ponderosa pine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Douglas-fir	0	0	283	275	202	0	486	567	40	0	—	728	20	81	—	—	61	40	418	405
Grand fir	0	0	364	534	1,093	0	101	2,833	283	54	—	4,452	91	971	—	—	340	227	189	1,599
Total																	412	280	607	2,186
Grand fir/mountain maple habitat type																				
No. of stands	**7**	**3**	**6**	**8**	**17**	**2**	**0**	**0**	**8**	**1**	**1**	**2**	**5**	**3**	**1**	**1**	**37**	**9**	**8**	**11**
Western larch	12	863	94	0	38	0	—	—	0	0	0	0	0	0	0	0	20	288	71	0
Ponderosa pine	0	27	54	51	38	162	—	—	20	0	162	0	0	0	0	0	22	45	61	37
Douglas-fir	173	27	135	223	114	202	—	—	243	0	648	0	0	0	81	0	138	54	192	162
Engelmann spruce	0	1,403	81	334	5	0	—	—	0	162	0	0	0	0	0	0	2	486	61	243
Grand fir	173	81	256	374	224	324	—	—	324	486	162	81	178	0	162	0	230	153	233	287
Total																	412	1,026	618	729

[1]CC = clearcut; GS = group selection cut; ST = seed—tree cut; SW = shelterwood cut.
[2]Insuffient data or not present.

Table 5—Average size of clearcuts and group selection cuts for two central Idaho grand fir habitat types

Habitat types	Clearcuts	Group selection cuts
Grand fir/white spirea	4.0 acres (1.6 ha)	0.4 acres (0.16 ha)
Grand fir/mountain maple	3.3 acres (1.3 ha)	0.6 acres (0.24 ha)

with less cover (fig. 2). The 26 to 50 percent overstory cover class had the best representation of different regeneration species; that is where the largest numbers of western larch and Douglas-fir seedlings were found. In the 0 to 25 percent and more than 50 percent overstory cover classes, western larch and Douglas-fir seedlings were a smaller proportion of the regeneration; in both cases, grand fir accounted for almost 80 percent of the total number of seedlings.

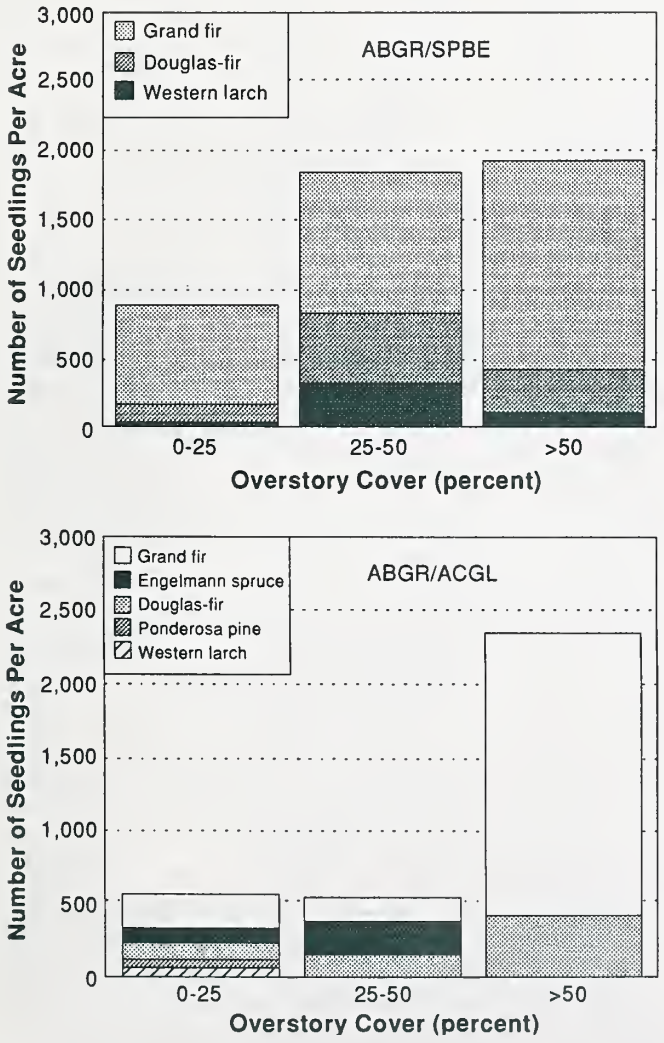

Figure 2—Number of conifer seedlings per acre under three overstory-cover categories for two central Idaho grand fir habitat types.

Shelterwood cutting most likely mimics historical stand conditions in ABGR/SPBE. Prior to the 1900's, ABGR/SPBE stands probably experienced frequent low-intensity fires, which likely maintained an overstory of predominantly fire-resistant species such as ponderosa pine at the expense of less fire-resistant species such as grand fir. Though the present site condition of sampled shelterwood stands may imitate the historical conditions, the present overstory composition probably does not because the sample stand composition leans heavily toward grand fir (table 6). The presence of this large amount of grand fir overstory relative to other species possibly accounts for the large number of grand fir seedlings.

In the mesic site conditions found in ABGR/ACGL, shelterwood cutting likely offers no advantages over other harvest-regeneration methods (table 4). In ABGR/ACGL, group selection cuts, which averaged 0.6 acres (0.24 ha), accounted for more regeneration, particularly of early and mid-seral species. The best mix of regeneration species occurred in the 0 to 25 percent overstory class; all of the western larch and most of the ponderosa pine were found there. In the 26 to 50 percent class, mid-seral Douglas-fir, late seral Engelmann spruce, and climax grand fir accounted for all the regeneration. The overstory cover class of more than 50 percent had almost four times as many seedlings as the 0 to 25 percent and 26 to 50 percent overstory cover classes. However, almost 83 percent of the regeneration was grand fir. Douglas-fir was the only other species found with the grand fir.

Clearcuts, which averaged 3 acres (1.2 ha), supported the least regeneration. This possibly relates to a lack of seed sources close by and the potential for tall shrubs to expand to their maximum in clearcuts. The edge effect of group selection cuts may reduce tall shrub expansion, especially in long, narrow units. Shelterwood cuts may also reduce vegetation development through shading. However, the resulting regeneration tends toward later seral species. As with ABGR/SPBE, the overstory of sampled shelterwoods consisted of more grand fir than of other species.

Site Preparation Treatments

Four site preparation treatments are most often used in central Idaho to modify existing safe sites: no site disturbance, burning, light scarification, and heavy

Table 6—Average overstory percent cover by total overstory cover categories, diameter at breast height, and species for two central Idaho habitat types

Habitat type and species	Total overstory cover (percent)								
	0-25 percent			25-50 percent			>50 percent		
	Diameter at breast height (inches)								
	[1]4-12	12-18	>18	4-12	12-18	>18	4-12	12-18	>18
	Percent								
Grand fir/white spirea habitat type									
Lodgepole pine	<1	0	0	0	0	0	4	0	0
Western larch	<1	0	0	<1	0	0	0	0	0
Ponderosa pine[2]	2	0	<1	13	<1	0	10	4	<1
Douglas-fir	<1	<1	<1	3	0	0	0	8	0
Grand fir	<1	<1	<1	10	10	1	19	11	0
Total		5			37			57	
Grand fir/mountain maple habitat type									
Lodgepole pine	0	0	0	0	0	0	0	0	0
Western larch	<1	<1	0	0	0	0	0	0	0
Ponderosa pine	<1	<1	<1	5	<1	<1	0	0	0
Douglas-fir	<1	<1	<1	5	5	2	0	0	0
Engelmann spruce	<1	<1	<1	2	<1	<1	0	0	0
Grand fir	3	<1	<1	9	3	3	38	15	0
Total		7			34			53	

[1]4-12 inches (9.8 to 30.5 cm); 12-18 inches (30.5 to 45.7 cm); >18 inches (>45.7 cm).
[2]Ponderosa pine in 4- to 12-inch (9.8- to 30.5-cm) diameter at breast height size class primarily planted.

scarification (table 7). Light scarification treatments remove or incorporate residual duff with minimal disturbance below the top 6 inches (15.2 cm) of mineral soil. Light scarification often produces a mix of soil surfaces from mineral soil to residual duff to "churned" organics. "Churned" soil surfaces result where organic matter has been incorporated into underlying mineral soil. These soil surfaces often occur where logging equipment turns or where machinery or logs move over a site, mixing organics and mineral soil without scraping it away. Such soil surfaces often consist of small mounds and depressions. Loose soil and organics compose the mounds, while depressions most often consist of mineral soil. Some slash piling operations, particularly on gentle slopes, produce light scarification. Conversely, heavy scarification removes the duff and most of the top 6 inches (15.2 cm) of soil. Contour terracing or stripping and slash piling on steeper slopes often results in heavy scarification.

Site response to burning usually varies depending on burning intensity. Many shrub species survive burning (Lyon and Stickney 1976; Noste and Bushey 1987; Stickney 1985) and will quickly resprout. Some shrub species, especially snowbrush ceanothus and redstem ceanothus (*Ceanothus sanguineus*), produce seeds that remain viable in the soil for 200 to 300 years and that germinate following a heat treatment (Conard and others 1985). Burning treatments and no site preparation were less common in ABGR/SPBE and ABGR/ACGL compared to scarification. However, as with harvest-regeneration methods, sample stand distribution in different age groups likely reflects common past practices (table 7). For example, no 5- to 9-year-old no site disturbance or burned sample stands were found in ABGR/ACGL, though in both age groups of 10 to 14 years and 15 to 19 years, 42 percent of the sample stands received either no site disturbance or burning. In ABGR/SPBE in all age groups, most sites received scarification; all of the sites received some site preparation, and 14 percent of the sample stands were burned. ABGR/SPBE more often occurs on gentle slopes (sample stands averaged 30 percent slope) that lend themselves to mechanical site preparation. The ABGR/ACGL habitat type more often occurs on steeper slopes (sample stands averaged 51 percent slope) that often limit site preparation options.

In most cases, scarification treatments, primarily light scarification, resulted in the most seedlings per acre in both habitat types. Douglas-fir, however, was a notable exception in ABGR/SPBE where the average number of Douglas-fir seedlings was about the same for burning and scarification. Douglas-fir, a mid-seral species, appears to require some site protection in the warm, dry ABGR/SPBE habitat type As noted previously, few Douglas-fir seedlings occurred in the open in ABGR/SPBE; most were found either under

Table 7—Average number of 3- to 10-year-old seedlings per acre by 5-year age groups (years since disturbance) and site preparation treatments for two central Idaho grand fir habitat types

Habitat type and species	Years since disturbance																Average			
	5-9				10-14				15-19				20-24							
	ND[1]	BB	LS	HS	ND	BB	LS	HS	ND	BB	LS	HS	ND	BB	LS	HS	ND	BB	LS	HS
Grand fir/white spirea habitat type																				
No. of stands	**0**	**1**	**8**	**1**	**0**	**1**	**7**	**2**	**0**	**0**	**6**	**1**	**0**	**3**	**5**	**0**	**0**	**5**	**26**	**4**
Western larch	—[2]	0	111	0	—	0	58	0	—	—	40	0	—	0	32	—	—	0	65	0
Ponderosa pine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Douglas-fir	—	0	243	0	—	971	416	0	—	—	162	0	—	27	32	—	—	210	230	0
Grand fir	—	0	425	0	—	324	1,445	0	—	—	1,052	0	—	108	275	—	—	130	816	0
Total																	—	340	1,111	0
Grand fir/mountain maple habitat type																				
No. of stands	**0**	**0**	**20**	**4**	**5**	**3**	**8**	**3**	**4**	**1**	**3**	**4**	**0**	**2**	**6**	**2**	**9**	**6**	**37**	**13**
Western larch	—	—	158	20	0	0	81	0	0	0	0	0	—	0	0	0	0	0	103	6
Ponderosa pine	—	—	40	0	113	54	10	54	0	162	0	40	—	0	0	0	63	54	24	25
Douglas-fir	—	—	166	142	113	27	111	270	0	648	540	81	—	0	0	40	63	121	158	137
Engelmann spruce	—	—	368	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grand fir	—	—	247	263	130	297	192	459	162	162	513	263	—	0	54	364	144	175	225	324
Total																	270	350	510	492

[1]ND = no site disturbance; BB = broadcast burn; LS = light scarification; HS = heavy scarification.
[2]Insufficient data or not present.

shelterwoods or a shrub canopy cover. Burning often increases shrub cover. Many top-killed shrubs resprout vigorously, and shrub densities may increase from buried seed germination. *Ceanothus* commonly occurs following burning in many central Idaho habitat types (Steele and Geier-Hayes 1988, 1992).

More ponderosa pine seedlings were found on sites with no site disturbance than on sites with other treatments in ABGR/ACGL. However, most of these seedlings resulted from seed caches. Seed caching may play an important role in ponderosa pine establishment. In the Oregon Cascade Range, West (1968) found 15 percent of the ponderosa pine seedlings resulted from animal caches. In central Idaho, a similar proportion of animal-cached ponderosa pine seedlings (11 percent) were reported by McConkie and Mowat (1936). The yellowpine chipmunk (*Eutamias amoenus*) may be responsible for many of the caches (Medin 1984), though Clark's nutcracker (*Nucifraga columbiana*) may also be involved (Lanner 1980). I defined a seedling cache as a group of seedlings originating from the same point. Some animals cache single seeds. However, I could not identify those caches from noncached seedlings nor could I identify caches with only one survivor. In ABGR/ACGL, 27 percent of the total seedlings occurred in caches. One no site preparation sample plot had a large number of cached seedlings. This plot had an extensive cover of blue huckleberry (*Vaccinium globulare*) and russet buffaloberry (*Shepherdia canadensis*), both potential food sources for small mammals. The coincidence of shrub and conifer seed food sources on this site may have resulted in the large number of cached ponderosa pine seedlings. Factoring out obviously cached seedlings from all treatments, more regeneration established on scarified sites than on sites without site disturbance or sites with burning.

In ABGR/SPBE habitat type, the largest total number of seedlings occurred on sample plots where 61 to 80 percent of the plot had been disturbed either from site preparation treatments or harvest-regeneration activities (fig. 3). Much less regeneration occurred on sites with 41 to 60 or 81 to 100 percent disturbance. In ABGR/ACGL, the largest total number of seedlings were found on sample sites with 41 to 60 percent disturbance. Large numbers of seedlings were also found on sites with 61 to 80 and 81 to 100 percent disturbance. However, grand fir seedling numbers increased with increasing disturbance.

This indicates that it is not necessary to thoroughly disturb a site to obtain adequate natural regeneration. In ABGR/SPBE, around 70 percent well-dispersed disturbance appears adequate; more thorough disturbance may actually retard natural regeneration establishment in this warm, dry habitat type. In ABGR/ACGL, well-dispersed disturbance over half or more of the plot appears to produce natural regeneration. As opposed

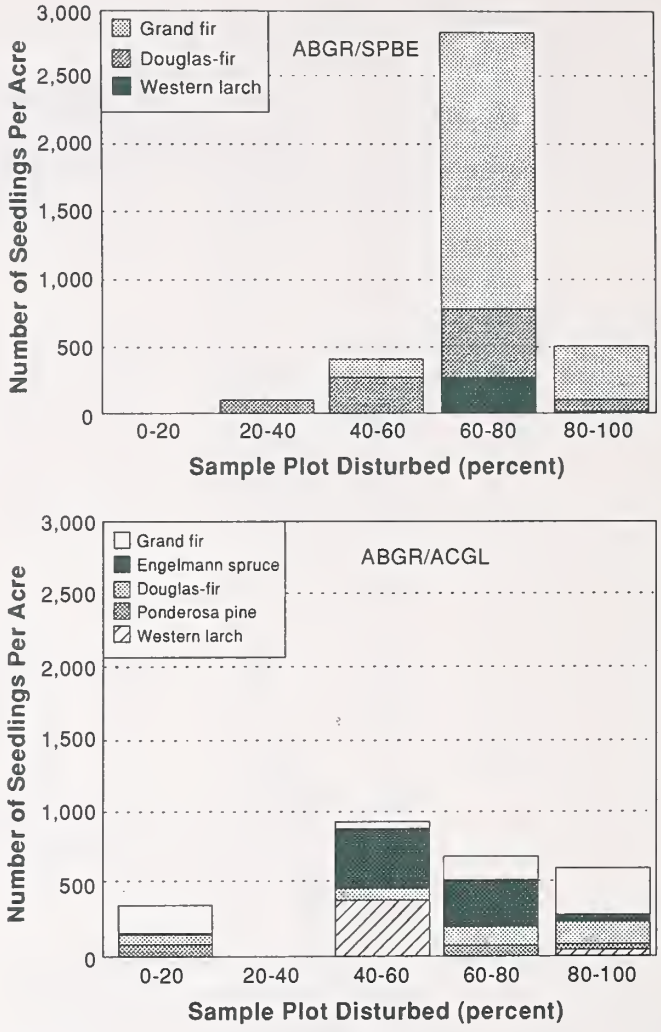

Figure 3—Number of conifer seedlings per acre on five area-disturbed categories for two central Idaho habitat types.

to ABGR/SPBE, natural regeneration numbers do not drop off with increasing disturbance. However, increasing disturbance only increased grand fir seedlings, even though grand fir established on residual duff when other species did not.

Soil Surface Covers

Soil surface covers change through time (table 8). In both habitat types, the amount of bare mineral soil declined while litter-covered mineral soil increased, though the process was slower in ABGR/SPBE than in ABGR/ACGL. Bare mineral soil and litter-covered mineral soil were the most common soil surface covers. For most species in both habitat types, bare mineral and litter-covered mineral soil were efficient soil surface covers (table 9). Bare mineral soil obviously benefits seedling establishment; a seedling radicle can penetrate into mineral soil unheeded. The litter on

Table 8—Soil surface covers by 5-year age groups (years since disturbance) for two central Idaho grand fir habitat types

Habitat type and surface cover	Years since disturbance			
	5-9	10-14	15-19	20-24
Grand fir/white spirea habitat type				
No. of stands	**10**	**10**	**7**	**8**
Bare mineral soil	[1]96 [2](49.3)	90 (33.4)	97 (48.4)	70 (23.6)
Litter-covered mineral soil	86 (39.8)	92 (58.6)	83 (43.4)	100 (77.0)
Residual duff	12 (27.5)	6 (79.3)	6 (42.5)	3 (2.0)
Moss mat	30 (6.6)	36 (13.3)	51 (8.3)	15 (4.0)
Rotten wood	10 (6.3)	4 (11.0)	9 (3.5)	3 (0.5)
Nonstockable	38 (7.2)	24 (3.9)	46 (6.7)	15 (4.7)
Grand fir/mountain maple habitat type				
No. of stands	**24**	**19**	**12**	**10**
Bare mineral soil	79 (32.6)	71 (33.1)	57 (17.4)	38 (9.6)
Litter-covered mineral soil	93 (58.9)	100 (55.6)	92 (77.5)	94 (84.5)
Residual duff	3 (31.8)	0 (0.0)	8 (66.0)	8 (64.8)
Moss mat	71 (16.4)	76 (13.3)	43 (4.5)	44 (2.2)
Rotten wood	16 (9.2)	15 (5.6)	12 (26.6)	16 (5.4)
Nonstockable	24 (7.1)	39 (5.9)	23 (9.1)	28 (11.1)

[1]Percentage of sample plots.
[2]Percentage of sample plot area.

Table 9—Soil surface regeneration efficiencies for 3- to 10-year-old seedlings in two central Idaho grand fir habitat types

Habitat type and surface cover	Species				
	Western larch	Ponderosa pine	Douglas-fir	Engelmann spruce	Grand fir
Grand fir/white spirea habitat type					
No. of seedlings	**21**	**—[1]**	**87**	**0**	**269**
Bare mineral soil	[2]2	—	3	—	2
Litter-covered mineral soil	3	—	3	—	3
Residual duff	—	—	4	—	4
Moss mat	5	—	5	—	5
Rotten wood	—	—	4	—	5
Grand fir/mountain maple habitat type					
No. of seedlings	**49**	**26**	**110**	**94**	**184**
Bare mineral soil	3	3	3	3	2
Litter-covered mineral soil	1	3	2	1	3
Residual duff	—	—	5	—	5
Moss mat	5	4	4	5	4
Rotten wood	—	4	3	3	2

[1]Insufficient data or not present.
[2]Class 1: very inefficient; Class 2: inefficient; Class 3: neutral; Class 4: moderately efficient; Class 5: very efficient.

litter-covered mineral soil may retard soil surface evaporation rates by acting as a mulch; some investigations have shown that litter-covered mineral soil may be particularly important in dry environments (Day and Duffy 1963; Krauch 1956).

In dry ABGR/SPBE, bare mineral soil was an inefficient soil surface cover for western larch and grand fir while litter-covered mineral soil was efficient. Here, the potential mulching properties of litter may be important, especially for western larch that occurs only on more moist sites in ABGR/SPBE. Additionally, litter-covered soil surfaces probably get some site protection from the vegetation providing the litter because the litter usually remains close to the source. In this case, it may be a soil surface and canopy cover combination that provides the safe site; most western larch seedlings in ABGR/SPBE were found on sites with 26 to 50 percent overstory cover. In ABGR/ACGL, bare mineral soil was an efficient soil surface cover for western larch while litter-covered mineral soil was very inefficient. ABGR/ACGL may support tall shrubs, which likely retard early seral western larch development. Here, most western larch seedlings occurred in the open, away from a potential litter source; all the western larch seedlings were found on sites with 0 to 25 percent overstory cover.

Moss mats, which most often resulted from light scarification and sometimes burning, were found in both habitat types, though they were more common in the mesic ABGR/ACGL. In ABGR/SPBE, the highest proportion of moss mats occurred in the 15- to 19-year-old age group, while in ABGR/ACGL moss mats occurred more often on recently disturbed sites. Moss mats were very efficient or more efficient soil surface covers for all species in both habitat types. I could not determine if seedlings established on the moss mats or if the moss mats developed after seedling establishment. But moss mats have been identified in other studies as important seedbeds (Day and Duffy 1963). Moss mats, like litter, may act as a mulch, creating a more moist rooting environment than surrounding areas, or moss mats may indicate a microsite that is suitable for both the moss and the seedling.

While residual duff may act as a mulch like litter, only grand fir in ABGR/ACGL habitat type established on it. Residual duff, in contrast to litter, usually occurs in thick, matted layers, while litter usually occurs as a single layer of undecomposed leaves, needles, or twigs. Residual duff, especially in ABGR/SPBE, may dry out before a seedling's radicle can reach mineral soil. Small amounts of residual duff occurred in most age groups in both habitat types. When present, residual duff often covered a substantial proportion of the sample plot.

All age groups in both habitat types had some rotten wood, though rotten wood was more common in ABGR/ACGL. Rotten wood was a very efficient and moderately efficient soil surface cover in ABGR/SPBE. In ABGR/ACGL, rotten wood was efficient or moderately efficient for all species except grand fir. Rotten wood can act as a water reservoir and therefore an important source of moisture, especially in dry environments (Amaranthus and others 1989). In this study, rotten wood had higher regeneration efficiency values in the drier ABGR/SPBE habitat type than the mesic ABGR/ACGL.

Safe Site Covers

Seedlings occurred more often under the direct influence of vegetation or debris in ABGR/ACGL than in ABGR/SPBE (table 10) even though few seedlings were found in the open in ABGR/SPBE (table 3). ABGR/SPBE supports less vegetation compared to ABGR/ACGL; in ABGR/SPBE most seedlings not occurring under the direct influence of a safe site cover were found in shelterwoods. ABGR/ACGL supports more vegetation. Therefore, fewer open safe sites are probably available, especially as the vegetation develops through time. Seedlings in ABGR/ACGL, particularly of more seral western larch and ponderosa pine, occurred more often in the open especially immediately following disturbance.

Forbs were the most common safe site cover in both habitat types followed by graminoids, white spirea, and ceanothus in ABGR/SPBE and ceanothus, Scouler willow (*Salix scouleriana*), and slash in ABGR/ACGL (table 11). Forbs and graminoids, with two exceptions, were very inefficient or inefficient safe site covers in both habitat types. In ABGR/SPBE several safe site covers were moderately efficient or very efficient for more than one seedling species including white spirea, ponderosa pine, and grand fir. Scouler willow varied from neutral to very efficient. Ceanothus was neutral. In ABGR/ACGL, moderately efficient or very efficient safe site covers were currant (*Ribes* spp.), elderberry (*Sambucus* spp.), and western larch. Ceanothus was mostly neutral. Scouler willow was neutral to moderately efficient. Sitka alder was moderately efficient for Engelmann spruce and inefficient for grand fir. Blue huckleberry ranged from inefficient to very efficient.

The presence of certain cover species may indicate suitable environments for a particular conifer species. This is particularly true for Engelmann spruce and western larch, both of which are usually found in more moist habitat types or in more moist extremes of drier habitat types. For example, sites that are moist enough to support prickly currant (*Ribes lacustre*) are usually well suited for Engelmann spruce.

Table 10—Safe site cover regeneration efficiencies for 3- to 10-year-old seedlings in two central Idaho grand fir habitat types

Habitat type and surface cover	Species				
	Western larch	Ponderosa pine	Douglas-fir	Engelmann spruce	Grand fir
Grand fir/white spirea habitat type					
No. of seedings	**21**	—[1]	**87**	**0**	**269**
	Percent				
Seedling occurrence					
No safe site cover	67	—	37	—	50
Under safe site cover	33	—	63	—	50
	Regeneration efficiency				
Forbs[2]	—	—	[3]2	—	2
Graminoids	3	—	2	—	2
White spirea (*Spiraea betulifolia*)	5	—	4	—	4
Ceanothus (*Ceanothus velutinus*)	—	—	3	—	3
Slash	—	—	3	—	2
Ponderosa pine (*Pinus ponderosa*)	—	—	4	—	4
Scouler willow (*Salix scouleriana*)	5	—	4	—	3
Cherry (*Prunus* spp.)	—	—	3	—	—
Currant (*Ribes* spp.)	—	—	—	—	2
Snowberry (*Symphoricarpos* spp.)	—	—	—	—	2
Grand fir (*Abies grandis*)	—	—	5	—	4
Quaking aspen (*Populus tremuloides*)	—	—	—	—	—
Utah honeysuckle (*Lonicera utahensis*)	—	—	—	—	5
Douglas-fir (*Pseudotsuga menziesii*)	—	—	—	—	—
Rose (*Rosa* spp.)	5	—	—	—	3
Oregon-grape (*Berberis repens*)	—	—	—	—	—
Elderberry (*Sambucus* spp.)	—	—	—	—	—
Thimbleberry (*Rubus parviflorus*)	—	—	—	—	—
Lodgepole pine (*Pinus contorta*)	—	—	—	—	5
Ninebark (*Physocarpus malvaceus*)	—	—	—	—	—
Serviceberry (*Amelanchier alnifolia*)	—	—	—	—	—
Mountain maple (*Acer glabrum*)	—	—	—	—	—

(con.)

Table 10 (Con.)

Habitat type and surface cover	Species				
	Western larch	Ponderosa pine	Douglas-fir	Engelmann spruce	Grand fir
Grand fir/mountain maple habitat type					
No. of seedings	**49**	**26**	**110**	**94**	**184**
	Percent				
Seedling occurrence					
No safe site cover	40	35	12	24	22
Under safe site cover	60	65	88	79	78
	Regeneration efficiency				
Forbs	1	2	3	2	2
Ceanothus (*Ceanothus* spp.)	2	3	3	—	3
Scouler willow (*Salix scouleriana*)	4	3	3	4	4
Slash	2	3	2	2	2
Graminoids	—	—	2	1	1
Thimbleberry (*Rubus parviflorus*)	5	—	4	5	2
Currant (*Ribes* spp.)	5	—	4	4	4
Sitka alder (*Alnus sinuata*)	—	—	—	4	2
Ponderosa pine (*Pinus ponderosa*)	—	3	3	—	3
Blue huckleberry (*Vaccinium globulare*)	4	5	4	2	4
Mountain maple (*Acer glabrum*)	—	—	2	—	4
Ninebark (*Physocarpus malvaceus*)	—	—	2	—	3
Utah honeysuckle (*Lonicera utahensis*)	—	4	4	—	4
White spirea (*Spiraea betulifolia*)	—	5	3	—	3
Grand fir (*Abies grandis*)	—	5	2	—	2
Douglas-fir (*Pseudotsuga menziesii*)	—	—	—	—	4
Cherry (*Prunus* spp.)	—	—	2	—	2
Snowberry (*Symphoricarpos* spp.)	—	—	2	—	2
Mountain-ash (*Sorbus scopulina*)	—	—	—	4	—
Rose (*Rosa* spp.)	—	5	—	—	4
Serviceberry (*Amelanchier alnifolia*)	—	—	—	—	—
Pachistima (*Pachistima myrsinites*)	5	—	—	—	—
Elderberry (*Sambucus* spp.)	—	—	—	5	5
Western larch (*Larix occidentalis*)	—	—	5	5	—
Russet buffaloberry (*Shepherdia canadensis*)	—	—	—	—	5
Oregon-grape (*Berberis repens*)	—	—	—	—	—
Clematis (*Clematis columbiana*)	—	—	5	—	—
Engelmann spruce (*Picea engelmannii*)	—	—	—	—	—
Big sagebrush (*Artemisia tridentata*)	—	5	—	—	—
Quaking aspen (*Populus tremuloides*)	—	—	—	—	—

[1]Insufficient data or not present.
[2]Arranged in order from most common to least common.
[3]Class 1: very inefficient; Class 2: inefficient; Class 3: neutral; Class 4: moderately efficient; Class 5: very efficient.

Table 11—Constancy and average canopy cover (in parentheses) for cover categories by 5-year age groups (years since disturbance) for two central Idaho grand fir habitat types

Habitat type and cover	Years since disturbance			
	5-9	10-14	15-19	20-24
Grand fir/white spirea habitat type				
Forbs	94 (33.6)	98 (18.1)	97 (20.2)	98 (25.4)
Graminoids	94 (9.5)	98 (9.5)	97 (14.8)	98 (12.0)
White spirea (*Spiraea betulifolia*)	44 (13.9)	54 (13.9)	71 (19.3)	53 (12.9)
Ceanothus (*Ceanothus velutinus*)	16 (1.5)	42 (19.1)	23 (22.6)	40 (38.1)
Slash	68 (10.2)	52 (7.8)	60 (11.9)	40 (8.2)
Ponderosa pine (*Pinus ponderosa*)	14 (3.5)	28 (7.8)	43 (11.9)	50 (23.4)
Scouler willow (*Salix scouleriana*)	20 (6.3)	22 (11.7)	11 (8.3)	20 (22.1)
Cherry (*Prunus* spp.)	8 (17.6)	16 (9.5)	0 (0.0)	23 (18.1)
Currant (*Ribes* spp.)	24 (19.7)	16 (2.6)	3 (0.5)	8 (10.0)
Snowberry (*Symphoricarpos* spp.)	16 (10.8)	2 (15.0)	20 (19.4)	18 (3.5)
Grand fir (*Abies grandis*)	4 (55.0)	16 (15.9)	6 (5.0)	3 (25.0)
Quaking aspen (*Populus tremuloides*)	0 (0.0)	0 (0.0)	17 (24.2)	13 (32.2)
Utah honeysuckle (*Lonicera utahensis*)	6 (6.7)	12 (8.3)	6 (2.8)	23 (8.3)
Douglas-fir (*Pseudotsuga menziesii*)	8 (3.3)	20 (6.9)	6 (20.3)	3 (2.0)
Rose (*Rosa* spp.)	22 (1.8)	6 (2.8)	11 (1.6)	43 (4.7)
Oregon-grape (*Berberis repens*)	0 (0.0)	8 (7.3)	3 (0.5)	10 (10.4)
Elderberry (*Sambucus* spp.)	6 (13.3)	4 (5.0)	0 (0.0)	0 (0.0)
Thimbleberry (*Rubus parviflorus*)	6 (5.2)	10 (6.2)	0 (0.0)	5 (1.5)
Lodgepole pine (*Pinus contorta*)	0 (0.0)	0 (0.0)	0 (0.0)	3 (20.0)
Ninebark (*Physocarpus malvaceus*)	6 (0.5)	2 (5.0)	6 (2.8)	0 (0.0)
Serviceberry (*Amelanchier alnifolia*)	0 (0.0)	10 (6.8)	0 (0.0)	0 (0.0)
Rocky mountain maple (*Acer glabrum*)	0 (0.0)	2 (0.5)	0 (0.0)	0 (0.0)
Grand fir/mountain maple habitat type				
Forbs	98 (23.3)	100 (14.4)	100 (24.7)	100 (17.2)
Ceanothus (*Ceanothus* spp.)	20 (15.8)	39 (32.7)	43 (31.2)	42 (43.0)
Scouler willow (*Salix scouleriana*)	37 (11.7)	27 (16.0)	37 (36.4)	28 (33.8)
Slash	83 (12.9)	67 (8.4)	55 (8.0)	28 (6.5)
Graminoids	96 (6.5)	86 (9.2)	82 (5.5)	100 (4.2)
Thimbleberry (*Rubus parviflorus*)	34 (23.5)	32 (17.7)	32 (11.8)	32 (13.0)
Currant (*Ribes* spp.)	60 (9.1)	63 (11.3)	22 (7.1)	40 (7.6)
Sitka alder (*Alnus sinuata*)	13 (36.5)	5 (30.0)	5 (53.3)	18 (63.2)
Ponderosa pine (*Pinus ponderosa*)	17 (9.8)	31 (19.3)	23 (21.8)	18 (33.9)
Blue huckleberry (*Vaccinium globulare*)	21 (4.5)	23 (24.9)	22 (19.0)	20 (30.0)
Mountain maple (*Acer glabrum*)	14 (6.4)	20 (19.8)	30 (17.3)	20 (21.4)
Ninebark (*Physocarpus malvaceus*)	20 (9.4)	25 (11.4)	22 (15.8)	34 (17.2)
Utah honeysuckle (*Lonicera utahensis*)	33 (8.0)	23 (11.0)	17 (8.3)	20 (3.5)
White spirea (*Spiraea betulifolia*)	27 (2.9)	24 (4.3)	18 (32.1)	34 (5.3)
Grand fir (*Abies grandis*)	9 (20.5)	12 (6.5)	5 (20.7)	12 (35.8)
Douglas-fir (*Pseudotsuga menziesii*)	16 (7.7)	18 (13.4)	13 (15.2)	4 (5.0)
Cherry (*Prunus* spp.)	1 (1.0)	5 (12.2)	15 (16.3)	18 (26.7)
Snowberry (*Symphoricarpos* spp.)	8 (7.1)	6 (10.7)	23 (11.7)	18 (14.1)
Mountain-ash (*Sorbus scopulina*)	9 (11.3)	4 (25.1)	5 (7.3)	2 (0.5)
Rose (*Rosa* spp.)	21 (2.6)	30 (2.8)	27 (2.3)	22 (1.3)
Serviceberry (*Amelanchier alnifolia*)	5 (2.0)	4 (3.0)	7 (22.6)	12 (10.0)
Pachistima (*Pachistima myrsinites*)	3 (8.0)	5 (17.2)	0 (0.0)	0 (0.0)
Elderberry (*Sambucus* spp.)	7 (9.8)	5 (2.4)	0 (0.0)	0 (0.0)
Western larch (*Larix occidentalis*)	0 (0.0)	1 (80.0)	0 (0.0)	0 (0.0)
Russet buffaloberry (*Shepherdia canadensis*)	0 (0.0)	5 (13.0)	0 (0.0)	0 (0.0)
Oregon-grape (*Berberis repens*)	0 (0.0)	1 (0.5)	7 (7.9)	6 (2.0)
Clematis (*Clematis columbiana*)	0 (0.0)	4 (5.5)	5 (3.7)	0 (0.0)
Engelmann spruce (*Picea engelmannii*)	0 (0.0)	2 (1.0)	0 (0.0)	6 (10.7)
Big sagebrush (*Artemisia tridentata*)	1 (0.5)	3 (8.5)	0 (0.0)	0 (0.0)
Quaking aspen (*Populus tremuloides*)	3 (4.0)	0 (0.0)	0 (0.0)	0 (0.0)

[1]Percentage of sample plots.

RECOMMENDATIONS

The harvest-regeneration and site preparation treatments required to produce adequate safe sites vary by habitat type (table 12). Natural regeneration in the warm, dry ABGR/SPBE habitat type appears to require more site protection, either from the overstory or understory, than natural regeneration in the mesic ABGR/ACGL habitat type. Where openings are created in ABGR/SPBE, site preparation that promotes or maintains a shrub component may be necessary to protect the regeneration. Usually, broadcast burning will produce more shrub cover than scarification. Low-intensity burns that produce scattered ceanothus and other shrubs are more desirable than high-intensity burns that produce a continuous shrub cover. Even though a shrub cover may be necessary to protect natural regeneration in openings on warm, dry habitat types, the benefits from reduced insolation and heat extremes are outweighed by the competition between the shrubs and regenerating conifers for moisture and light. Well-dispersed disturbance, either from burning or light scarification over about 70 percent of the site, appears to produce the best regeneration response. Too much or too little disturbance may not provide enough suitable or varied safe sites for all the potential species.

Historical natural disturbance in ABGR/SPBE most likely resulted in an overstory of fire-resistant, earlier seral species of western larch (in more moist portions of the habitat type), ponderosa pine, and some Douglas-fir. This study found that an overstory of at least 25 to 50 percent cover produced the most diverse regeneration. More cover (more than 50 percent) resulted in a larger component of grand fir. This may be because grand fir was the most common overstory cover and potential seed source, and the increased shade may have reduced earlier seral species establishment. Where possible, retaining an overstory of earlier seral species is more desirable not only for a seed source, but also from the standpoint of fire, insect, and disease hazards.

Site preparation treatment options for obtaining natural regeneration in the mesic ABGR/ACGL habitat type, where shrub competition can potentially exclude natural regeneration, are more limited than in ABGR/SPBE where environmental extremes somewhat reduce the shrub response. In the ABGR/ACGL habitat type, broadcast burning only top-kills existing shrubs, which quickly resprout. Additional shrubs may germinate from buried seed. Therefore, in the ABGR/ACGL habitat type, scarification treatments dispersed over at least 50 percent of the area are more effective than broadcast burning for obtaining natural regeneration. This may be particularly important for more seral species because shrub responses from scarification treatments can be minimized compared to broadcast burning depending on how much top-kill results from the treatment.

Table 12—Recommended harvest-regeneration and site preparation treatment combinations for natural regeneration in two central Idaho grand fir habitat types. Harvest-regeneration methods match site preparation treatments with the same letters

Species	Harvest-regeneration method				Site preparation treatment[1]			
	CC	GS[2]	ST	SW	ND	BB	LS	HS
Grand fir/white spirea habitat type								
Western larch				A2[3]			A2[4]	
Ponderosa pine				A		A	A	
Douglas-fir			A	B2		A	B2	
Grand fir				A3		A	A2	
Grand fir/mountain maple habitat type								
Western larch	A						A1[4]	
Ponderosa pine		A to A1[3]					A2	
Douglas-fir	A						A2/3	
Engelmann spruce		A to A3					A1	
Grand fir	A	A to A3					A3	

[1]CC = clearcut; GS = group selection cut; ST = seed-tree cut; SW = shelterwood cut; ND = no site disturbance, minimal disturbance to soil surfaces; BB = broadcast or underburn; LS = light scarification, removal or incorporation of organics from or into the top 6 inches of soil; HS = heavy scarification, removal of organics and the top 6 inches of soil.

[2]Size of group selections for grand fir/white spirea (ABGR/SPBE) = 0.4 acres; for grand fir/mountain maple (ABGR/ACGL) = 0.6 acres.

[3]Amount of overstory cover: 1 = 0-25 percent; 2 = 26-50 percent; 3 = more than 50 percent.

[4]Amount of disturbance: 1 = 40-60 percent of area; 2 = 60-80 percent of area; 3 = 80-100 percent of area.

Though currant seed may be stimulated to germinate from scarification, currants have sparser canopies than many other shrub species and are minimal competition for natural regeneration. In ABGR/ACGL, currants were moderately efficient and very efficient safe site covers.

More thorough scarification, which may increase the shrub response, appears to increase Douglas-fir and grand fir regeneration. Moss mats, an efficient or very efficient soil surface cover for all species, most commonly appear following scarification. Small (0.6-acre) openings or treatments that retain an overstory of less than 25 percent cover appear to produce adequate natural regeneration of all species. Retaining some overstory, possibly for seed, may somewhat reduce early seral and mid-seral shrub species response through overstory shading. Increased overstory shade, however, appears to benefit climax grand fir at the expense of other species, though Douglas-fir can regenerate under the increased shade.

No site preparation is usually not recommended for natural regeneration because all species, even late seral and climax, regenerate better on a disturbed soil surface.

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Natural regeneration of five conifer species was surveyed in two central Idaho grand fir habitat types. The habitat types range from warm, dry (grand fir/white spirea) to mesic (grand fir/mountain maple). Four harvest-regeneration methods and four site preparation techniques were sampled. Recommendations for obtaining natural regeneration vary primarily by habitat type. Conifer seedlings in the warm, dry grand fir/white spirea habitat type require site protection for establishment. In the mesic grand fir/mountain maple habitat type, tall shrub potential can reduce the opportunity to establish early seral conifer species.

KEYWORDS: silviculture, site preparation, safe sites, overstory cover

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